III.D.1 Correlations Between Theory and Experiment

The primary means of producing the critical parameters in this section were the GAMTEC II code for the 18-group cross section sets and the HFN diffusion theory code for the critical parameters (some additional checks were made with the DTF-IV code). At this writing only critical parameters for plutonium-natural uranium mixtures with the plutonium consisting of only ^{239}Pu have been calculated. This limitation was set because correlation of calculation and experiment found that calculated k-effective values were consistently low when large fractions of ^{240}Pu, ^{241}Pu, and ^{242}Pu were involved (see pp. III.A.1-3 to -5.) if the calculation assumed that the ^{239}Pu represented the ^{239}Pu and ^{241}Pu and the ^{240}Pu represented the ^{240}Pu and the ^{242}Pu. However, recent experiments with plutonium-uranium nitrate solutions (1) have provided a good correlational basis for mixture calculations and two-isotope calculations do not appear to be as low as the plutonium-only data indicated (possibly because of compensating errors).

The uranium and plutonium analysis is shown in Table I for both the actual composition (in weight percent) and those used for the calculations. Only the single plutonium composition was used for the sphere calculations because the amount of the 238, 241, and 242 plutonium isotopes was not considered significant.

(1) R. C. Lloyd, et. al., "Critical Parameters of Plutonium-Uranium Nitrate Solutions," Transactions of the American Nuclear Society, 15, 803, 1972.

TABLE I

All Experiments	Actual	Calculations Used	
^{234}U	0.01	0	0
^{235}U	0.66	0.66	0.66
^{236}U	0.01	0	0
^{238}U	99.32	99.34	99.34
Sphere Experiments			
^{238}Pu	0.01	0	---
^{239}Pu	95.09	95.09	---
^{240}Pu	4.66	4.68	---
^{241}Pu	0.22	0.22	---
^{242}Pu	0.01	0.01	---
Cylinder Experiments		(2-Iso)	(5-Iso)
^{238}Pu	0.07	0	0.07
^{239}Pu	73.00	76.22	73.00
^{240}Pu	22.80	23.78	22.80
^{241}Pu	3.22	0	3.22
^{242}Pu	0.91	0	0.91

The computer codes used included HFN, DTF-IV, and KENO (all with GAMTEC II generated cross section decks) and HAMMER. The data is shown in Table II. Additional details may be found in the reference. The sphere was fully reflected by water and the cylinder was fully reflected on the radius and the base.

Previous experience has shown the Δk effect of the gadolinium to be less than calculated. Therefore, the calculated k-effective for the spheres would be expected to be slightly higher if no gadolinium were present. The total calculated gadolinium effect is 2.2, 2.3, and 0.3 percent k-effective, therefore, the adjustment would be small.

The differences in k-effective between the two isotope and five-isotope calculations are .0154, .0152, .0150, .0150, and .0150.

This compared to values greater than 0.03 that might be expected at 25 percent ^{240}Pu + ^{242}Pu based on the correlation in section III.A.1. The two-isotope calculations are also low by less than one percent k-effective compared to a predicted value of nearly two percent in III.A.1. These smaller differences may be due to the presence of large amounts of ^{238}U.

Based on these correlations it now appears feasible to calculate critical parameters for mixed solutions with up to 25 percent ^{240}Pu + ^{242}Pu with a one percent or less correction factor in k-effective.

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TABLE II

	Sphere			Cylinder				
Wall Thick., cm	0.112	0.122	0.122	0.079	0.079	0.079	0.079	0.079
Base Thick., cm	-----	-----	-----	0.9525	0.9525	0.9525	0.9525	0.9525
Radius, cm	17.869	19.304	19.314	30.514	30.514	30.514	30.514	30.514
Critical Height, cm	-----	-----	-----	50.27	54.66	61.04	70.49	84.86
U,g/l	157.1	75.7	264.9	390.2	394.5	399.0	403.3	407.1
Pu, g/l	70.93	35.05	45.6	30.63	29.00	27.32	25.71	24.28
Gd, g/l	0.051	0.025	0.005	-----	-----	-----	-----	-----
HNO_3, M	3.12	1.49	2.1	0.45	0.44	0.44	0.37	0.36
Two Isotopes For Pu and Two For U								
HFN-GAMTEC II	-----	-----	-----	0.9942	0.9922	0.9918	0.9922	0.9919
Five Isotopes For Pu and Two For U								
HFN-GAMTEC II	1.0071	1.0081	1.0062	1.0096	1.0074	1.0068	1.0072	1.0069
DTF-GAMTEC II	-----	1.0216	-----	-----	-----	-----	-----	-----
HAMMER	-----	1.029	1.024	-----	-----	-----	-----	-----
KENO-GAMTEC II	1.017	1.007	0.992	1.003	1.003	1.002	1.014	1.006
	$\pm$.008	$\pm$.008	$\pm$.008	$\pm$.007	$\pm$.008	$\pm$.007	$\pm$.005	$\pm$.004
(neutron history)	9400	9400	9400	9600	10,000	10,000	13,000	14,000